CONCOMITANT IPSILATERAL FEMORAL NECK AND FEMORAL SHAFT FRACTURE NONUNIONS: A REPORT OF THREE CASES AND A REVIEW OF THE LITERATURE

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ABSTRACT

Ipsilateral femoral neck and femoral shaft fractures are rarely reported in the literature and represent a diagnostic and treatment challenge. Due to the possibility of missing a nonunion at either site, we recommend a high clinical suspicion and careful radiographic examination of both fracture sites. Because the development of nonunion at both sites is exceedingly rare, we report three cases of concomitant ipsilateral femoral neck and shaft nonunions that were treated by the senior author (KAE). Two patients were treated with a Pauwels osteotomy and a blade plate for the femoral neck nonunion and a reamed retrograde intramedullary nail for the shaft. One patient was treated with an antegrade reamed cephalomedullary intramedullary nail. All three patients' fractures united at a mean of 4.6 months and they are currently pain free and without physical limitations.

INTRODUCTION

To the best of our knowledge, ipsilateral femoral neck and shaft fractures treated surgically that have gone on to develop nonunions at both fracture sites have only been reported in the English literature six times in the last 25 years.[1,2] These six cases are reported as complications of larger case series, and there was no discussion of treatment for the ipsilateral femoral neck and shaft nonunions.[1,2]

Ipsilateral femoral neck and shaft fractures usually occur in multiply injured, younger patients from high velocity injuries. Retrospective reviews have demonstrated that femoral neck fractures in the setting of femoral shaft fractures may be missed in as many as 19-31 percent of femoral shaft fracture presentations.[3,4] Four methods for fixation of femoral neck and shaft fractures have received attention in the literature: (1) Initial prompt fixation with multiple cancellous screws for the femoral neck and an extra-articular retrograde intramedullary nail for the femoral shaft; (2) A cephalomedullary nail; (3) Antegrade intramedullary nailing with cancellous lag screws, and; (4) Plate fixation of the femoral shaft with lag screw fixation of the femoral neck. Due to the lack of randomized trials, it is unclear which method of fixation leads to fewer complications. Since the patient population is relatively young, successful treatment of the initial injury and subsequent treatment of ipsilateral lower extremity nonunions is important to avoid significant cumulative impact on quality of life.

Ipsilateral femoral neck and femoral shaft nonunions may present difficult diagnostic and treatment challenges. Diagnosis can be difficult because of referred pain and standard radiographic imaging limitations secondary to the presence of hardware. Furthermore, treatment is complicated by the previous hardware, and difficulty in selecting optimal methods secondary to the lack of literature on the topic.

We present three patients who sustained ipsilateral femoral neck and femoral shaft fractures that went on to nonunion at both sites, and a review of the literature on this topic. The purpose of this case series is to raise awareness of these ipsilateral femoral neck and shaft nonunions and to report our experience with them.

Case 1

A 38-year-old female fell from four stories and sustained the following injuries: a Pauwels-C femoral neck fracture, an ipsilateral 3A open right femoral shaft fracture (Figure 1), a 3A open right humeral shaft fracture, an LC-1 pelvic ring injury, and a right patella fracture. At the time of presentation, the femoral neck fracture was open reduced and stabilized with a dynamic hip screw and two-hole side plate, and the femoral shaft fracture was treated with a reamed retrograde femoral nail prior to patella fixation. The humerus fracture was also treated with irrigation and debridement and open reduction with internal fixation at the same surgery. At surgery there was noted to be bone loss at the femoral fracture site.

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Figure 1. An anteroposterior radiograph of the femur fractures of patient 1.

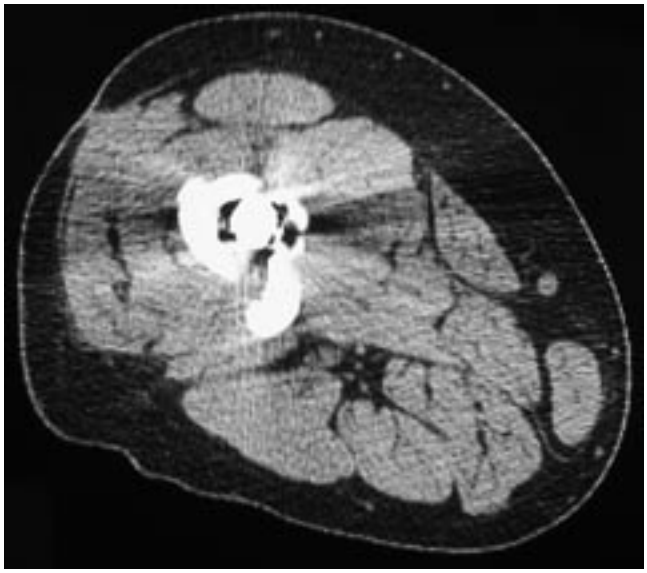

Figure 2. An axial cut of the thigh demonstrating the nonunion of the femoral shaft in patient 1.

Figure 3. An anteroposterior view of the proximal femur showing fixation with a cephalomedullary device with acceptable femoral neck shaft angle in patient 1.

The patient's postoperative course was unremarkable, and she was kept on protected weight bearing.

Six months after her original surgical procedures she complained of pain in her right thigh. Radiographs and CT scan (Figure 2) of the right hip and femur demonstrated nonunions of the femoral neck and shaft. Workup for infection was negative. She was neither a diabetic nor a smoker.

The patient underwent removal of existing hardware and exchange nailing of her femur with a locked, antegrade intramedullary nail with a cephalomedullary spiral blade (Figure 3) (Synthes, Paoli Pa). In addition, a mixture of cancellous bone graft with bone marrow aspirate and BMP-2 (Infuse® bone graft, Medtronic, Philadelphia, PA) impregnated collagen sponges was placed after opening the fracture sites. The patient was initially given instructions to be toe-touch weight bearing.

At six months the patient had three of four cortices healed in the femoral shaft and radiographic evidence of a healed femoral neck fracture. She had no complaints and was functioning well with regard to activities of daily living.

Figure 4. Radiograph demonstrating the Pauwels osteotomy with blade plate fixation and retrograde femoral nail after nonunion was diagnosed in patient 2.

Figure 5. An anteroposterior radiograph of the proximal femur showing ipsilateral femoral neck and shaft fractures in patient 3.

Case 2

A 37-year-old male was struck by a motor vehicle while riding a motorcycle and sustained the following injuries: Closed ipsilateral right femoral neck and shaft fractures and a right open extra-articular calcaneus fracture. The patient was treated elsewhere with a reamed, antegrade cephalomedullary nail with a derotational screw for both femur fractures. The calcaneus fracture was treated with repeat irrigation and debridement and casting.

Six months after his original injuries, the patient presented to the senior author and described severe pain in his right thigh and groin that confined him to a wheelchair. Radiographs demonstrated nonunions of both the femoral shaft and neck fractures with intact hardware. The femoral neck had fallen into varus alignment.

At revision surgery, the hardware was removed and, due to the varus neck alignment, a Pauwels osteotomy was performed to restore anatomic alignment. A 30° wedge of bone was removed from the lateral cortex, and a 130° blade plate was inserted under fluoroscopic imaging. Next, a reamed retrograde nail was inserted and locked in compression. Autogenous graft from the bone wedge was placed around the osteotomy site, and an implantable bone stimulator was used. Postoperative anteroposterior radiographs show the Pauwels osteotomy, blade plate, and retrograde nail (Figure 4).

The patient was made foot-flat weight bearing and discharged from the hospital on postoperative day four. At five months, radiographs confirmed union at both sites and the patient was advanced to full weight bearing. The patient did complain of a leg length discrepancy that measured two centimeters. The leg length discrepancy was successfully treated with a shoe lift.

Figure 6. An anteroposterior radiograph of the proximal femur demonstrating possible nonunion of the femoral neck and femoral shaft in patient 3. The radiograph also shows varus malposition of the femoral neck.

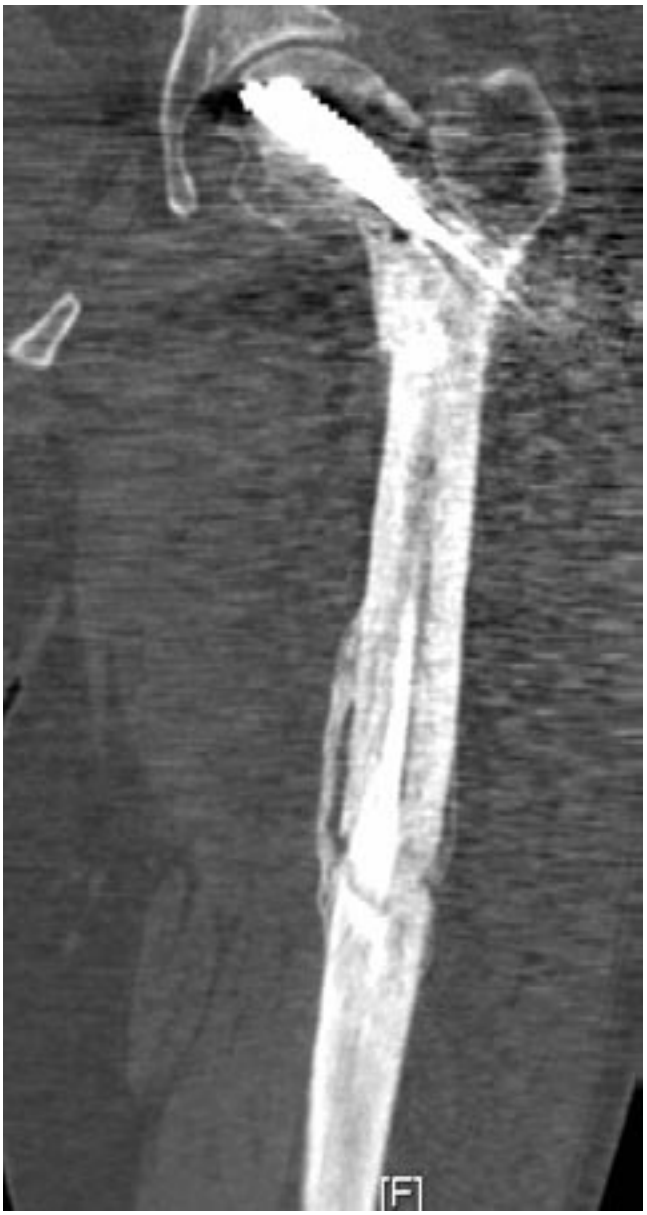

Figure 7. A CT coronal reconstruction showing a nonunion of the femoral neck and shaft in patient 3.

Case 3

A 30-year-old male with a neuromuscular condition was struck by a motor vehicle while riding a motor scooter. He sustained the following injuries: A displaced Pauwels-C left femoral neck fracture (Figure 5), a 3A open left femoral shaft fracture, a left open radius and ulna fracture, and a left tibia fracture. The femoral neck fracture was treated elsewhere with three cannulated screws and the femoral shaft was treated with a reamed retrograde femoral nail.

At two months follow-up, the patient still had hip and thigh pain, and there were minimal radiographic signs of bone healing at either site. After four months of treatment with a bone stimulator, the pain did not improve and there was no sign of healing. Plain radiographs demonstrated that the hip had fallen into varus malalignment and that the cannulated screws were backing out (Figure 6). Computed tomography (CT) scan was obtained which confirmed ipsilateral nonunions of the neck and shaft of the femur (Figure 7).

Figure 8. This radiograph demonstrates the Pauwels osteotomy with blade plate fixation and retrograde femoral nail in patient 3.

Seven months after the patient's initial surgery, the patient was taken to the operating room and the cannulated screws, as well as the intramedullary nail, were removed. Again, because of the neck malalignment, a Pauwels osteotomy with removal of a 40° bone wedge was performed, followed by placement of a 130° blade plate (Figure 8). Autogenous bone graft from the removed wedge was then placed in the osteotomy site. Next, a reamed retrograde femoral nail was inserted across the shaft nonunion. After irrigation, a bone stimulator was placed with leads to both the osteotomy site and femoral shaft. The patient was placed on foot-flat weight bearing status.

At ten weeks the patient was without pain and there was radiographic evidence of fracture healing. The patient was advanced to 30 pounds weight bearing. At three months there was abundant callus at the shaft and the patient was advanced to weight bearing as tolerated. During healing, as the neck fracture settled into a stable position, the blade plate appeared to advance into the foveal region on radiographs. However, the patient had no groin or thigh pain. Nine months after surgery for the ipsilateral nonunions, the patient was without pain and full weight bearing. Due to concern regarding the position of the blade plate, the plate was removed. The patient tolerated the procedure well and seven months after the removal of hardware was without pain and was back to pre-injury status.

DISCUSSION

Ipsilateral femoral neck and shaft fractures usually occur in young patients who sustain multiple injuries from high energy trauma. The reported number of femoral shaft fractures that have accompanying femoral neck fractures is thought to range between 2.5 to six percent.[5-8] Five to 43 percent of femoral neck fractures go on to nonunion, and the reported rate for femoral shaft nonunion is two to ten percent.[1,4,9-11] The incidence of ipsilateral femoral neck and shaft fractures that go on to nonunion is not known.

It is possible that ipsilateral femoral neck and shaft fractures are more likely to go on to nonunion than isolated femoral neck or femoral shaft fractures for two reasons: (1) Ipsilateral injury is more likely to be a high energy injury, and thus may have increased vascular disruption, and (2) The free segment between the femoral neck and shaft fractures may create more motion at the proximal and distal fracture sites than would be encountered at an isolated femur fracture site. Other injury and patient factors increase the likelihood of ipsilateral injuries progressing to nonunion, such as smoking, significant soft tissue disruption, use of unreamed small-diameter intramedullary nails for the femoral shaft fracture, and prolonged delay in weight bearing.[2,12] Each of our patients had risk factors for the development of nonunion: Open fracture, bone loss, and smoking. In addition, all of the patients sustained multiple trauma and numerous fractures. Each, however, healed all the fractures sustained other than the ipsilateral femoral neck and shaft fractures.

Nonunions of ipsilateral femoral neck and shaft fractures are rare. A review of the literature over the past 25 years only mentions six cases of treated ipsilateral femoral neck and shaft fractures that both went on to nonunion. Ideally, initial management would decrease the number of nonunions that occur with these fractures. In 1987, Swiontkowski reviewed 20 case series comprising 176 cases that implemented 60 different methods of treatment.[4] Since 1987, the number of methods for treatment and devices for internal fixation have increased. Determining the best method for fixing these combined fractures at presentation continues to be supported more by subjective reasoning than by scientific data due to the lack of controlled studies. Currently, lag screw fixation of the femoral neck fracture and reamed intramedullary nailing of the shaft is the preferred method of fixation for the initial injury.[2,13] However, antegrade intramedullary nailing with a cephalomedullary device, or plating of the femur fracture are also possibilities depending on fracture characteristics and surgeon preference. The priority when approaching these combined fractures should be anatomic reduction and stabilization of the femoral neck fracture, since delayed or inappropriate treatment of the femoral neck fracture can lead to avascular necrosis of the femoral head in a young individual. Additionally, prompt internal fixation decreases non-orthopaedic complications, particularly in the pulmonary system, in multiply injured trauma patients.[14]

Six to eight months may pass before a potential delayed union can be considered a nonunion, owing to the protracted length of time that femoral shaft and femoral neck fractures require to heal.[15] Clinical diagnosis of ipsilateral femoral neck and shaft nonunions is challenging since the patient may be experiencing referred pain from one of the nonunion sites that masks the pain from the second nonunion site. Additionally,

the hardware in place may decrease radiographic visibility of a nonunion. The lack of a specific definition of a nonunion and the above factors specific to ipsilateral femoral neck and shaft fractures may necessitate the use of an intraoperative exam.

After the ipsilateral nonunions have been diagnosed, there is very little in the literature to guide treatment. Of the previous six ipsilateral femoral neck and shaft nonunions, five appear in a case series by Watson et al. and one is published in a case series by Wiss et al.[1,2] The article by Wiss et al. does not state how the ipsilateral nonunions were treated. The five ipsilateral nonunions in the case series by Watson et al. were treated in the following ways: Two were treated with a long hip screw and a plate, one was treated with a hip screw and a reamed retrograde nail, one was treated with a blade plate and a reamed retrograde nail, and the last one was treated with a hip screw and an exchange nail. The exchange nailing failed and had to be converted to a compression plate.

Due to the small number of patients in this series and the small number of patients reported in the literature, we cannot make any specific recommendations on the ideal choice of fixation for ipsilateral femoral neck and shaft nonunions. We do recommend correcting any malalignment of the femoral neck with a Pauwels osteotomy. If femoral neck varus is present, we recommend first performing the osteotomy with correction and provisional fixation of the osteotomy site. At this point, either a long side-plate that extends beyond the shaft nonunion site may be applied and fixed with further soft tissue dissection, or an intramedullary nail may be placed. We would recommend that a retrograde intramedullary nail that overlaps the proximal plate be used, especially in cases in which an intramedullary nail is already in place. This allows for a less invasive approach to the femoral shaft nonunion. Exchange nailing in the face of femoral shaft nonunion has been shown to be successful in 78.3 percent of cases.[16] For younger individuals, we recommend treating both the femoral neck and femoral shaft nonunions during the same surgical setting to eliminate the need for a second surgery and decrease rehabilitation time. If two implants are used, one for each nonunion site, the devices should overlap in order to prevent a stress riser. If infection is suspected as a cause of the nonunion, appropriate preoperative labs (erythrocyte sedimentation rate, C-reactive protein, and white blood cell count), should be obtained. In addition, intraoperative cultures should be obtained and the patient treated appropriately postoperatively.

Intertrochanteric osteotomy is used in the treatment of femoral neck nonunions in order to convert the principally shear forces acting on the fractured femoral neck into compressive forces. At no time is the nonunion site exposed. Healing of the nonunion is purely due to alteration in the biomechanical forces at the femoral neck. The technique relies on careful preoperative planning and meticulous attention to surgical detail. Good quality biplanar radiographs are essential. Classically, the amount of the wedge resection is based on the angle the fracture line makes with the femoral shaft. The operation is performed at the intertrochanteric level. A 30 to 60^0 wedge is removed from the lateral cortex and the osteotomy site fixed with a 95 to 120^0 blade plate, depending on the size of the wedge removed. The blade should enter the proximal fragment two centimeters proximal to the osteotomy site, and its tip should lie in the inferior quadrant of the femoral head.[17] Patients should be kept partial weightbearing for six to 12 weeks until fracture and osteotomy site unions have occurred.

Marti et al. reported on 50 patients treated with an intertrochanteric abduction osteotomy of Pauwels.[18] The authors treated all patients less than age 70 with this operation, regardless of the presence of femoral head necrosis. Eighty-six percent of their patients healed their femoral neck fractures. Seven patients went on to hip arthroplasty, but only three of these were performed for persistent nonunion.

Anglen reported his series of 13 patients ages 18-59 who underwent intertrochanteric osteotomy for femoral neck nonunion.[17] Twelve of the 13 patients united radiographically and clinically. Good functional results, as measured by SF-36 testing, were seen in 11/13 patients.

In the case of elderly patients with limited mobility who have ipsilateral femoral neck and shaft nonunions, our treatment would change. We would consider a hip arthroplasty, either hemi- or total, depending on the patient's functional status following successful healing of the femoral shaft with an intramedullary nail. Allowing for healing of the femoral nonunion prior to implantation of a hip prosthesis allows the orthopaedic surgeon to perform a standard primary hip arthroplasty. Our opinion is that preoperative labs to rule out infection, as well as intraoperative cultures, should be undertaken prior to implantation of the hip prosthesis in these cases.

Treatment for ipsilateral nonunions should be dictated by the characteristics of the nonunions. When femoral neck varus malalignment is present, an osteotomy is usually required to achieve union. This, however, will limit the type of instrumentation that may be utilized. However, with careful planning and meticulous care, patients with nonunions of the femoral neck and shaft can be successfully treated with good outcomes.

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